ECOSYSTEM RESTORATION STRATEGY

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This paper outlines the CALFED vision and strategy for restoring a healthy Bay-Delta system. This strategy is based on the restoration of ecosystem elements (habitats and plant and animal populations and communities) and natural processes (functions) that support the elements. A healthy ecosystem is one that exhibits a natural array, quantity, and quality of habitats and associated populations and communities of desirable species of plants and animals. A healthy ecosystem also has natural processes that meet the basic needs of the desirable plants and animals.

The ecosystem restoration program is based on a mission, vision, objectives, and strategy for ecosystem restoration. Among these, the mission, vision, and objectives are expected to change little as the Program proceeds. The strategy, guided by adaptive management, will likely be the subject of continuing adjustment of actions as restoration efforts proceed and as stressors change. An essential part of an ecosystem restoration strategy is a plan for ensuring that restoration activities continue to occur until objectives are achieved, and that adequate provisions are made for the continued maintenance and protection of the restored system. Included in this strategy paper is a description of the conditions that must be met to assure proper protection and management of a restored bay-Delta ecosystem.

PURPOSE OF THIS DOCUMENT

The CALFED Bay-Delta Program is developing a comprehensive solution to resource problems of the Bay-Delta system. These problems are related to water supply reliability, water quality, levee system integrity, and ecosystem restoration. An Ecosystem Restoration Strategy is needed to provide the overall approach and direction for development, implementation, and management of an ecosystem restoration program.

This strategy document achieves four purposes:

- describes CALFED's vision of a restored ecosystem;
- describes the strategy to develop, implement, and manage the restoration program;
- demonstrates that the strategy is based on an ecosystem approach guided by flexible adaptive management; and
- serves as a focus to develop understanding and support for the restoration program among stakeholders and the public.

VISION OF A RESTORED ECOSYSTEM

CALFED is working to achieve a healthy Bay-Delta ecosystem that provides for the needs of plants, animals, and people using the system. This healthy ecosystem will include a range of sustainable habitat types that provide environmental, recreational, and aesthetic benefits. It will support natural production of an abundance of resident and anadromous fish, including viable recreational and commercial fisheries. A healthy ecosystem will also support sustainable production and survival of plant and wildlife species, including resident species as well as migrants such as the waterfowl that use the Pacific Flyway each winter. These qualities are the benefits or ecosystem services that a healthy Bay-Delta ecosystem will provide.

These sustainable fish, wildlife, and plant populations depend on an ecosystem that provides all the natural processes, called ecosystem functions, that they need. Though the Bay-Delta system will never be returned to the conditions that existed prior to human disturbance, ecosystem functions will be restored to levels needed to support Bay-Delta species at natural sustainable levels and at levels where they will not be threatened or endangered with extinction. A healthy functioning ecosystem will include all the habitats necessary for survival of species that use the system, including for example freshwater and brackish tidal marsh, shallow water, riparian woodlands, and shaded riverine areas. These habitats will be large enough in area to support sustainable populations of Bay-Delta species, and will be interconnected to allow movement and prevent isolation of plant or animal populations. To the extent possible, natural processes of the system will be restored, including for example proper water flow to ensure appropriate salinity levels, meander belts that create necessary habitat and generate sediments that are important to the system, and nutrients that support the food web of the system. Human pursuits that affect the Bay-Delta ecosystem will be managed to complement ecosystem health, maintaining water that is free of toxic contaminants, and encouraging agricultural land uses that are compatible with wildlife.

PROBLEMS AND PROGRAM OBJECTIVES

The CALFED Bay-Delta Program has developed problem and objective statements for each of the four critical resource areas being addressed by the Program: ecosystem quality, water supply reliability, water quality, and levee system vulnerability. Problems were identified and objectives set through an open process involving a series of public workshops, meetings of the Bay-Delta Advisory Council, and other public and agency input. Problems were identified first, and then an objective was developed to correspond to each problem. A program mission statement completes the statement of objectives.

The Program mission and major objective statements for ecosystem quality are reproduced below. The full set of ecosystem quality objectives is reproduced in an appendix to this document. Finally, the Program has documented all its problems and objectives in a "Problem/Objective Definition" paper dated March 1996.

Program Mission

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system.

Major Ecosystem Quality Objectives

The primary ecosystem quality objective and the first level of subobjectives are listed below.

Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.

A. **Improve and Increase Aquatic Habitats** so that they can support the sustainable production and survival of native and other desirable estuarine and anadromous fish in the estuary.

B. **Improve and Increase Important Wetland Habitats** so that they can support the sustainable production and survival of wildlife species.

C. **Increase population health and population size** of Delta species to levels that assure sustained survival.

BAY-DELTA ECOSYSTEM SERVICES, FUNCTIONS, AND LIMITING FACTORS

Three concepts that are central to the CALFED ecosystem restoration program are *ecosystem services, ecosystem functions*, and *limiting factors*. An ecosystem service is a benefit (i.e. output) of an ecosystem provided to humans. Examples of ecosystem services may include:

- water supply valued for multiple beneficial uses,
- a sustainable and relatively-complete Bay -Delta ecosystem mosaic (valued for its recreational and aesthetic qualities),
- sustainable populations of commercially and recreationally valuable fish species (such as chinook salmon, steelhead, and striped bass),

- sustainable populations of other special-status plant and animal species (such as Delta and longfin smelt, splittail, green sturgeon, greater sandhill crane, and other native fish, animal, and plant species), and

- capability to absorb flood flows without damaging land uses and infrastructure.

An ecosystem function is a process in an ecosystem that determines the ecosystem's ability to provide a corresponding service. Ecosystem functions include processes within and between ecosystems that contribute to the development and maintenance of the ecosystem and therefore control its ability to provide services. Critical ecosystem functions that are impaired may constitute limiting factors for populations of fish or other organisms that comprise important ecosystem services. Ecosystem functions may include:

- nutrient cycling, through aquatic, wetland and upland habitats

- hydrological and hydraulic regimes, within Bay/Delta water courses that support food web, transport, habitat, and migration of aquatic species

- primary and secondary productivity, that support the aquatic food web

- connectivity between important related and dependent aquatic, wetland, and upland habitats

- transport of early life stages of fish populations from spawning grounds to nursery areas

Limiting factors include food supply, lack of important habitat, lack of aquatic flows, and poor water quality. Any one or combination of factors may limit populations of valuable plant and animal species.

Those ecosystem functions and limiting factors that are well known and documented to control or limit important fish populations or other important ecosystem services will be focus of the CALFED Program. For example, certain water diversions are well known to severely affect important fish populations during critical life stages and screening of these high priority diversions can be broadly accepted for full implementation in the CALFED Program.

Other ecosystem functions or limiting factors may require additional study to more conclusively demonstrate their causal relationships to important ecosystem services. These functions or factors requiring more investigation will be excellent candidates for addressing using an Adaptive Management approach. For example, the direct causal relation between certain flow

patterns (e.g. seasonally) in the Delta and the survival of a fish population may be less well known. This relation could be investigated using a pilot project that manipulates flows and monitors the fish population to determine the benefit or impact of those flows; subsequent flow patterns would be adaptively managed based on the results of the pilot project.

PROGRAM STRATEGY

The vision is the picture of what we want the Bay-Delta ecosystem to look like when we've achieved our mission. The strategy is how we will get to and accomplish the vision.

The Program's strategy is to reverse the decline in ecosystem health by reducing or eliminating factors which degrade habitat, impair ecological functions, or reduce the population size or health of species. The Program will focus on those factors that cause direct mortality of plants and animals in the system, or cause indirect mortality by degrading habitat conditions or functions. Program objectives reflect this strategy. In addition the strategy also emphasizes the following.

Limiting Factors When there is a single factor limiting an ecological function or species, remedial actions are often clear. However, there are many stressors that reduce ecological functions or cause mortality of species in combination or at different stages in the species life cycle. Often the processes are complex and poorly understood. In the Bay-Delta system, some of these include inadequate physical habitat for reproduction, foraging, or escaping from predators; inadequate water quality including temperature and toxic contaminants; fragmented habitat that impedes migration; inadequate or altered water flow regimes; direct and indirect mortality caused by water diversions from the system; the presence of undesirable introduced species that compete with or prey upon other species; recreational and commercial harvest; and or even such factors as recreational boating. In cases where there are multiple stressors affecting species, the strategy of the Program is to take a broad ecosystem approach, making incremental improvements in all the significant identified factors that affect important species and their habitats.

The Program will start by addressing factors likely limiting species of special concern such as winter and spring run chinook salmon, delta smelt, and Sacramento splittail. Subsequent efforts will work to protect or restore other ecosystem functions. Actions will be guided toward de-listing these species as threatened or endangered.

Natural Processes With limiting factors as the focus of the program, there will be need to select actions that favor those factors that take advantage of natural processes to achieve desired results. This will reduce the amount of effort necessary to sustain restoration benefits, and increase the likelihood of long-term success of the program.

Resilience Actions will be prioritized by their ability to restore some of the system's natural resilience to disturbance. Habitat restoration will be directed toward natural processes such as

river meander belts that are self sustaining. Actions will also be spread throughout the system, to ensure genetic diversity will be protected for species with widespread distributions.

Achieving Multiple Benefits Efforts will be made to increase benefits by selecting or designing actions that improve habitat conditions or ecological functions for multiple species. Actions will also be favored if they improve other resource areas including water quality, system integrity, and water supply reliability as well as improving ecosystem quality.

Measurable Results Program results will be measured through monitoring and research. Actions will first be designed and implemented so that their effectiveness is measurable. The Program will include monitoring to assess the overall success of actions implemented. This will allow adaptive management of the restoration effort: adjustment of our actions to make them more effective, and changes in emphasis as the condition of the ecosystem improves.

Adaptive Management Where uncertainty exists in how to implement actions or on potential benefits, adaptive management will guide the program. Actions will be implemented on a pilot scale to refine uncertainty techniques and to measure previously unknown potential success. The Program will adjust as necessary to achieve objectives. In many cases natural variability in the ecosystem will also force Program adjustments.

Make up for Unavoidable Losses Where competing uses of Bay-Delta resources make it impossible to avoid indirect affects on species, habitats, or ecological functions, efforts will be made to compensate by reducing other causes of mortality or improving habitats and functions elsewhere in the Bay-Delta system.

Specific Restoration Program Actions

Sacramento River: Habitat restoration in the upper Sacramento River would include the following:

- protection and enhancement of the remnant natural meander belt from Redding downstream to Chico Landing,
- maintenance of adequate flows for fish spawning, rearing, and migration,
- restoration of spawning gravel habitat for salmon and Steel Head from Keswick Dam downstream to below the Red Bluff Diversion Dam,
- reductions in the amount of toxins released into Spring Creek and the upper Sacramento River from the Iron Mountain Mine,
- improvement in water temperatures below Keswick Dam through installation of temperature control devices on Whiskeytown and Shasta Dams,
- improvements in riparian habitat through setback levees from Chico Landing to Verona, and
- improvement in the riparian and aquatic habitat and drainage systems in the Yolo and Sutter bypasses,

- reductions in fish losses at diversions from Keswick Dam downstream to the Delta.

Sacramento River Tributaries: Habitat restoration in the Sacramento River tributaries would include the following:

- comprehensive improvement in riparian and aquatic habitat,
- removal of barriers to migration,
- improvement in flow conditions, and
- reductions in fish losses at diversions

San Joaquin River: Habitat restoration in the San Joaquin River would involve the following:

- improvement in channel habitat conditions upstream of the Delta,
- reductions in fish losses at diversions, and
- improvements in flows for fish spawning, rearing, and migration.

San Joaquin River Tributaries: Habitat restoration in the San Joaquin River tributaries would include:

- better management of flows and pulse flows,
- improvements in riparian habitat and vegetation,
- restoration of natural processes or artificial maintenance of physical habitat such as spawning gravels,
- reduction in fish losses in diversions, and
- improvements in channel habitat configurations.

Bay-Delta: Habitat restoration in the Bay-Delta would include the following:

- conversion of substantial acreage of leveed land to tidal wetlands and shallow aquatic habitat in Suisun Marsh and the Delta,
- restoration of Delta riparian and shallow water habitat along levees,
- protection and enhancement of riverine habitats on channel islands,
- protection and enhancement of existing tidal wetlands,
- reductions in fish losses at diversions,
- improvements in flows through and out of the Delta, and
- protection and enhancement of agricultural land uses and practices that support wildlife.

The specific CALFED strategy is described by geographic subunit of the Bay-Delta and its watershed in Table 1. The table displays actions related to function and limiting factors being addressed, species benefitted, indicators and target levels, and how the action would be implemented. Though some target levels are presented, development of targets and goals is a primary focus of later phases of the program.

The CALFED restoration program will be coordinated with other long-term restoration programs in the Central Valley including the following:

- Comprehensive Conservation Management Plan - EPA/SFEP
- Central Valley Fish and Wildlife Restoration Program - USFWS
- Anadromous Fish Recovery Plan - AFRP
- Salmon and Steel Head Management Plan - DFG
- Recovery Plans For ESA (Delta Native Fishes, Winter-Run Chinook Salmon, Salt Marsh Harvest Mouse, Swainson's Hawk, Giant Garter Snake, etc.)
- Battle Creek, Deer, Mill Creek Restoration Plans (MOU's)
- Corps Sacramento River Bank Protection Project Comprehensive Corridor Management Plan
- Upper Sacramento River Fisheries And Riparian Habitat Management Plan - SB 1086
    - Riparian Habitat Restoration Plan
    - Fisheries Restoration Plan
- San Joaquin River Habitat Restoration Plan
- Lower Mokelumne River Management Plan
- Central Valley Habitat Joint Venture/North American Waterfowl Management Plan

The CALFED Ecosystem Restoration Program will focus efforts by watersheds. In this way, the Program can take advantage of existing or planned restoration efforts in the various watersheds of the Central Valley.

INDICATORS AND TARGETS

Indicators are factors to be measured in a monitoring program to provide a measure of progress. Benchmarks that indicate performance (i.e. good or bad) will help establish specific target levels. The following is a list of potential indicators and targets. Details on indicators are available in a report from the Indicators Workshop convened to provide input on this topic. Indicators and targets will be a focus of discussions by the BDAC Ecosystem Restoration Workgroup.

Water Quality: nutrients (phosphorous, nitrogen/nitrate, carbon [TOC, DOC, POC]), wastewater discharge, water temperature, salinity, toxics (heavy metals, organic pesticides, hydrocarbons-petrochemicals, noxious algal blooms, BOD, water clarity, etc.

Wetland habitat quantity/quality:

Riparian habitat quantity/quality:

Shallow water aquatic habitat:

Other aquatic habitat indicators: location of X2, salinity gradient, net freshwater inflow and outflow, San Joaquin River flow, Sacramento River flow, Delta outflow, water depth, velocity, and substrate.

Food Web Indicators: chlorophyll a, phytoplankton (marine neritic diatoms, Melosira), rotifers, copepods (Eurytemora, Acartia), cladocera (Daphnia, Bosmina), and shrimp (Crangon, Neomysis).

Inhibitors: BOD, water hyacinth, Asian clams, boat traffic, agricultural drains, water diversions/intakes, fish predators, wildlife predators, and toxic chemicals.

Community assemblage: healthy assemblage of native fishes, lack of many exotics species.

Population indicators: species presence/absence; density, birthrate, growth rate, mortality rates, productivity/ reproductive rate; age distribution, population dispersion/distribution, population size, and harvest rates.

Individual indicators: growth rates, disease/parasites factors, fecundity, condition, diet and food uptake.

ADAPTIVE MANAGEMENT

The CALFED Bay-Delta Program Ecosystem Restoration Strategy is underpinned by the principle of active adaptive management. Its premise is that looking for a single best response to address a resource management issue or conflict is not sufficient to deal with the uncertainties in our complex system. Because our knowledge can never be complete, the proper direction lies in the design of opportunistic approaches based on what we know and continuous "learning by doing."

In normal practice, managers restore or manipulate habitats, primarily to achieve a management objective, rather than to find out how the system works. However, a management scheme is always an experiment. Attempts to selectively optimize environmental conditions for the benefit of a selected suite of species have proven largely unsuccessful in either achieving desired increases in target populations, or in achieving gains in the conservation of overall biodiversity. Implementation of habitat restoration and ecosystem function rehabilitation on a landscape scale will provide meaningful tests of success.

Linking monitoring and adaptive management will insure that environmental managers will acquire greater technical expertise and will develop greater confidence in the scientific methods. Because many of the issues relevant to sustainable ecosystem management through adaptation will require actions at a number of decision-making levels simultaneously, the concept of "learning by doing" must also be broad enough to include policy initiatives.

The CALFED Bay-Delta Program Ecosystem Restoration Component will be guided by our mission and strategy and modified by adapting to system response as measured through comprehensive monitoring. Policy direction will be sufficiently flexible to respond to increasing technical experience and scientific confidence.